

CGPET

Comprehensive Revision Notes

Chhattisgarh Pre Engineering Test

Physics | Chemistry | Mathematics

High-Priority Topics Marked | All Chapters | Exam Tips and Tricks

PHYSICS

CHEMISTRY

MATHEMATICS

Prepared for CGPET aspirants. Covers complete syllabus with key concepts, formulas, important laws, and exam tips. Star marks indicate high-weightage topics based on CGPET patterns.

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Ch 1 ** Units, Dimensions & Measurement

■ Key Concepts

- SI base units: m, kg, s, A, K, mol, cd
- Supplementary: radian (plane angle), steradian (solid angle)
- Dimensional formula: expresses quantity in M, L, T, I, theta, N, J
- Significant figures and rounding rules
- Systematic vs random errors; absolute, relative, percentage error

■ Important Formulas

Relative error = $\frac{\Delta A}{A}$

% error = $(\frac{\Delta A}{A}) \times 100$

For $Z = A^p \times B^q$: $\frac{\Delta Z}{Z} = p(\frac{\Delta A}{A}) + q(\frac{\Delta B}{B})$

■ Dimensional analysis - 2-3 questions guaranteed every year

- Use dimensional analysis to derive formulas or verify answers
- Remember: angle, solid angle, strain, refractive index are dimensionless

- Significant figure arithmetic is a common error source - practice rounding
- $\cos(\theta)$, $\sin(\theta)$ arguments must be dimensionless

Ch 2 *** Kinematics

■ Key Concepts

- Scalar vs vector; distance vs displacement; speed vs velocity
- Uniform acceleration; equations of motion
- Projectile motion: parabolic path
- Relative motion in 1D and 2D
- Circular motion: angular velocity, centripetal acceleration

■ Equations of Motion (Uniform Acceleration)

$v = u + at$

$s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2as$

$s_n = u + a\frac{(2n-1)}{2}$ (distance in nth second)

■ Projectile Motion

Range $R = \frac{u^2 \sin(2\theta)}{g}$ (max at $\theta = 45^\circ$)

Max Height $H = \frac{u^2 \sin^2(\theta)}{2g}$

Time of flight $T = \frac{2u \sin(\theta)}{g}$

At any point: $v_x = u \cos(\theta)$ (const), $v_y = u \sin(\theta) - gt$

■ Projectile and relative motion - high frequency topic

- Split 2D problems into independent x and y components
- For max range: $\theta = 45^\circ$; complementary angles give same R
- River-boat problems: use vector addition of velocities

- Do not confuse distance and displacement
- In projectile, horizontal velocity is constant; vertical acceleration = g

Ch 3 *** Laws of Motion

■ Newton's Three Laws

- 1st Law: Inertia - body at rest/uniform motion unless acted upon

- 2nd Law: $F = ma$ (net force = mass x acceleration)
- 3rd Law: Every action has equal and opposite reaction
- Conservation of linear momentum: if $F_{\text{net}} = 0$, $\sum(p) = \text{constant}$

■ Friction

Static friction: $f_s \leq \mu_s N$

Kinetic friction: $f_k = \mu_k N$

Rolling friction < Sliding friction < Static friction (max)

■ Circular Motion

Centripetal force: $F_c = mv^2/r = m\omega^2 r$

Banking angle: $\tan(\theta) = v^2 / rg$

Conical pendulum: $T = 2\pi \sqrt{L \cos(\theta) / g}$

■ Free body diagram problems - essential skill

■ Always draw FBD first; resolve forces along and perpendicular to motion

■ Pseudo-force = $-ma$ in non-inertial frames

■ Reaction force acts on a different body - not same as net force = 0

■ Normal force is NOT equal to weight on incline or accelerating lift

Ch 4 *** Work, Energy & Power

■ Key Formulas

Work $W = F \cdot d \cdot \cos(\theta)$ (scalar product)

KE = $(1/2) m v^2$

PE (gravity) = mgh

Work-Energy Theorem: $W_{\text{net}} = \Delta KE$

Power $P = W/t = F v \cos(\theta)$

Efficiency $\eta = (\text{useful output} / \text{total input}) \times 100\%$

■ Elastic Collision

$v_1 = [(m_1 - m_2)u_1 + 2m_2 u_2] / (m_1 + m_2)$

$v_2 = [(m_2 - m_1)u_2 + 2m_1 u_1] / (m_1 + m_2)$

$e = (v_2 - v_1) / (u_1 - u_2)$ [coefficient of restitution]

■ Conservation of energy + collision numericals are very common

■ In elastic collision: KE conserved; in perfectly inelastic: max KE lost

■ Spring PE = $(1/2)kx^2$; at natural length PE = 0

Ch 5 *** Rotational Motion

■ Key Concepts

- Torque $\tau = r \times F = I\alpha$
- Angular momentum $L = I\omega$; conserved when $\tau_{\text{ext}} = 0$
- Moment of inertia $I = \sum(m r^2)$
- Parallel axis theorem: $I = I_{\text{cm}} + Md^2$
- Perpendicular axis theorem (lamina): $I_z = I_x + I_y$

■ Standard Moments of Inertia

Solid sphere: $I = (2/5) MR^2$

Hollow sphere: $I = (2/3) MR^2$

Solid cylinder / disc: $I = (1/2) MR^2$

Rod about centre: $I = ML^2/12$

Rod about end: $I = ML^2/3$

■ Rolling without Slipping

$$v_{cm} = R\omega$$

$$KE_{total} = (1/2)Mv^2 + (1/2)I\omega^2 = (1/2)Mv^2(1 + I/MR^2)$$

$$\text{Fraction of rotational KE: } (I/MR^2) / (1 + I/MR^2)$$

■ MOI and rolling motion - 3-4 marks expected

- For rolling: use energy conservation (no friction work done)
- Angular momentum conservation: skater pulling arms

Ch 6 ** Gravitation

■ Key Laws and Formulas

$$\text{Newton's law: } F = G \frac{m_1 m_2}{r^2} \quad (G = 6.67 \times 10^{-11} \text{ N.m}^2/\text{kg}^2)$$

$$g = GM/R^2 \text{ (surface); } g' = g(1 - 2h/R) \text{ for } h \ll R$$

$$g_{depth} = g(1 - d/R)$$

$$\text{Escape velocity: } v_e = \sqrt{2gR} = 11.2 \text{ km/s (Earth)}$$

$$\text{Orbital velocity: } v_o = \sqrt{gR} = v_e / \sqrt{2}$$

$$\text{Orbital period: } T^2 \text{ proportional to } r^3 \text{ (Kepler's 3rd law)}$$

■ Kepler's Laws

- 1st: Planets move in ellipses with sun at one focus
- 2nd: Equal areas swept in equal time ($L = \text{constant}$)
- 3rd: T^2 proportional to a^3 (semi-major axis)

■ Escape velocity, satellite orbital period - frequently tested

- g is max at poles, min at equator due to Earth's rotation
- Geostationary orbit: $T = 24 \text{ h}$, $r \sim 42,000 \text{ km}$

Ch 7 ** Properties of Matter

■ Elasticity

$$\text{Stress} = F/A; \text{ Strain} = \Delta L / L$$

$$\text{Young's modulus } Y = \text{Stress/Strain} = FL / (A\Delta L)$$

$$\text{Bulk modulus } K = -V\Delta P / \Delta V$$

$$\text{Modulus of rigidity } G = \text{Shear stress} / \text{Shear strain}$$

$$\text{Poisson's ratio } \sigma = \text{lateral strain} / \text{longitudinal strain}$$

■ Fluid Mechanics

$$\text{Pascal's law: pressure change transmitted equally in enclosed fluid}$$

$$\text{Archimedes: Buoyant force} = \rho_{\text{fluid}} \times V_{\text{submerged}} \times g$$

$$\text{Bernoulli: } P + (1/2)\rho v^2 + \rho gh = \text{constant}$$

$$\text{Torricelli: } v = \sqrt{2gh} \text{ (efflux velocity)}$$

$$\text{Stokes law: } F = 6\pi\eta r v; \text{ Terminal velocity } v_t = 2r^2(\rho - \sigma)g / 9\eta$$

■ Surface Tension

$$\text{Excess pressure in soap bubble: } 4T/R; \text{ liquid drop: } 2T/R$$

$$\text{Capillary rise: } h = 2T \cos(\theta) / (r\rho g)$$

■ Bernoulli's equation + surface tension - common numericals

Ch 8 *** Thermodynamics & Kinetic Theory

■ Laws of Thermodynamics

- 0th: Thermal equilibrium (basis of temperature measurement)
- 1st: $\Delta U = Q - W$ (energy conservation)

- 2nd: Heat flows spontaneously from hot to cold; entropy increases
- 3rd: Entropy approaches 0 as T approaches 0 K

■ Key Processes

Isothermal ($\Delta T=0$): $\Delta U=0$; $Q=W$; $PV=\text{const}$

Adiabatic ($Q=0$): $PV^\gamma = \text{const}$; $TV^{(\gamma-1)} = \text{const}$

Isochoric ($\Delta V=0$): $W=0$; $Q = \Delta U = nC_v\Delta T$

Isobaric ($\Delta P=0$): $Q = nC_p\Delta T$; $W = P\Delta V$

■ Kinetic Theory

$PV = nRT$ (ideal gas)

$KE_{\text{avg}} = (3/2) kT$ (per molecule)

$v_{\text{rms}} = \sqrt{3RT/M}$; $v_{\text{avg}} = \sqrt{8RT/\pi M}$; $v_{\text{mp}} = \sqrt{2RT/M}$

$C_p - C_v = R$; $\gamma = C_p/C_v$ (1.67 mono, 1.4 diatomic)

■ Carnot efficiency $\eta = 1 - T_L/T_H$ - exam favourite

- For adiabatic: work done by gas = $-\Delta U = nC_v(T_1 - T_2)$
- Specific heat at constant volume $C_v = (f/2)R$ where f = degrees of freedom

Ch 9 *** Waves & Sound

■ Wave Parameters

$v = f\lambda$; $\omega = 2\pi f$; $k = 2\pi/\lambda$

$y = A \sin(\omega t - kx)$ (travelling wave)

Speed in string: $v = \sqrt{T/\mu}$

Speed in gas: $v = \sqrt{\gamma P/\rho} = \sqrt{\gamma RT/M}$

■ Superposition & Interference

Beats frequency = $|f_1 - f_2|$

Standing wave: $y = 2A \cos(kx) \sin(\omega t)$

String fixed both ends: $f_n = n v / 2L$

Open organ pipe: $f_n = n v / 2L$

Closed organ pipe: $f_n = (2n-1)v / 4L$

■ Doppler Effect

$f' = f(v \pm v_o) / (v \mp v_s)$

+ numerator for observer approaching, - for receding

■ Standing waves + Doppler - 3-4 marks every year

- Closed pipe has only odd harmonics
- At resonance columns: $L = \lambda/4, 3\lambda/4, 5\lambda/4 \dots$

Ch 10 *** Electrostatics

■ Key Formulas

Coulomb's law: $F = k q_1 q_2 / r^2$ ($k = 9e9 \text{ N.m}^2/\text{C}^2$)

Electric field $E = F/q = kQ/r^2$

Electric potential $V = kQ/r$

Potential energy $U = k q_1 q_2 / r$

Gauss's law: $\Phi_E = q_{\text{enc}} / \epsilon_0$

■ Capacitors

$C = Q/V$; Parallel plate: $C = \epsilon_0 A / d$

With dielectric: $C = K \epsilon_0 A / d$

Series: $1/C = 1/C_1 + 1/C_2 + \dots$

Parallel: $C = C_1 + C_2 + \dots$

Energy: $U = \frac{1}{2}CV^2 = \frac{Q^2}{2C} = QV/2$

■ Capacitor combinations and energy - 4-5 marks expected

- Electric field inside conductor = 0; charge resides on surface
- For Gaussian surfaces: use symmetry (spherical/cylindrical/planar)

- Do NOT add potential as vector - it is a scalar!
- Field lines never cross; they go from + to - charge

Ch 11 *** Current Electricity

■ Key Formulas

Ohm's law: $V = IR$; $R = \rho L/A$

Temperature: $R_T = R_0(1 + \alpha \Delta T)$

Power: $P = VI = I^2 R = V^2/R$

Kirchhoff's laws: $\sum(I) = 0$ (junction); $\sum(V) = 0$ (loop)

Wheatstone bridge: $P/Q = R/S$ (balanced)

■ Cell and Battery

EMF: $\epsilon = I(R+r)$; Terminal voltage $V = \epsilon - Ir$

Max power from source: $R_{\text{ext}} = r$

Cells in series: $\epsilon_{\text{eff}} = \sum(\epsilon)$, $r_{\text{eff}} = \sum(r)$

Cells in parallel (same EMF): $\epsilon_{\text{eff}} = \epsilon$, $r_{\text{eff}} = r/n$

■ Kirchhoff's law circuit problems - 5+ marks

- Potentiometer measures EMF without drawing current
- Meter bridge is practical Wheatstone; balanced $\rightarrow$ no current in galvanometer

Ch 12 *** Magnetic Effects of Current

■ Key Formulas

Biot-Savart: $dB = \mu_0 I dl \times \hat{r} / (4\pi r^2)$

Long wire: $B = \mu_0 I / (2\pi r)$

Circular loop at centre: $B = \mu_0 I / (2R)$

Solenoid: $B = \mu_0 n I$

Force on current: $F = B I L \sin(\theta)$

Lorentz force: $F = q(\mathbf{v} \times \mathbf{B})$

Cyclotron radius: $r = mv/(qB)$; $T = 2\pi m / (qB)$

■ Magnetic Moment and Torque

$M = NIA$ (magnetic moment of coil)

Torque $\tau = MB \sin(\theta) = NIAB \sin(\theta)$

Moving coil galvanometer: $\theta = NIAB/k$

■ Force on current, Biot-Savart, galvanometer - frequent

Ch 13 ** Electromagnetic Induction & AC

■ Faraday and Lenz

EMF $\epsilon = -d(\Phi)/dt$ (Faraday)

$\Phi = BA \cos(\theta)$

Lenz's law: induced EMF opposes the change in flux

Self-inductance: $\epsilon = -L dI/dt$

Solenoid: $L = \mu_0 n^2 A l$

Energy in inductor: $U = (1/2) L I^2$

■ AC Circuits

$V_{rms} = V_0/\sqrt{2}$; $I_{rms} = I_0/\sqrt{2}$

Inductive reactance $X_L = \omega L$

Capacitive reactance $X_C = 1/(\omega C)$

Impedance $Z = \sqrt{R^2 + (X_L - X_C)^2}$

Resonance: $\omega_r = 1/\sqrt{LC}$; Power factor $\cos(\phi) = R/Z$

■ Resonance condition, LCR circuit - conceptually important

Ch 14 *** Ray Optics & Wave Optics

■ Ray Optics Formulas

Mirror formula: $1/v + 1/u = 1/f$ ($f = R/2$)

Magnification $m = -v/u$

Snell's law: $n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$

Critical angle: $\sin(C) = n_2/n_1$ ($n_1 > n_2$)

Lens formula: $1/v - 1/u = 1/f$

Lens maker's equation: $1/f = (n-1)(1/R_1 - 1/R_2)$

Power $P = 1/f(m)$; Combined: $P = P_1 + P_2$

■ Wave Optics

YDSE fringe width: $\beta = \lambda D/d$

Bright fringes: path difference $= n\lambda$

Dark fringes: path difference $= (2n-1)\lambda/2$

Single slit diffraction: first minima at $\sin(\theta) = \lambda/a$

Resolving power of telescope proportional to D/λ

■ Mirror/lens formula + YDSE - guaranteed 5-6 marks

■ Sign convention: distances from pole/optical centre; real object $\rightarrow u$ is negative

■ For concave mirror/lens: f is negative

■ Lens formula uses sign convention; mirror formula convention differs slightly

■ In YDSE, central fringe is always bright (path difference $= 0$)

Ch 15 *** Modern Physics

■ Photoelectric Effect

$E = hf = hc/\lambda$ (photon energy)

Einstein: $KE_{max} = hf - \phi$ (ϕ = work function)

Threshold frequency: $f_0 = \phi/h$

de Broglie wavelength: $\lambda = h/(mv) = h/\sqrt{2mKE}$

■ Atomic Models and Spectra

Bohr: $r_n = n^2 \cdot a_0$ ($a_0 = 0.529$ Angstrom); $E_n = -13.6/n^2$ eV

Rydberg: $1/\lambda = R(1/n_1^2 - 1/n_2^2)$; $R = 1.097 \times 10^7$ m⁻¹

Lyman (UV): $n_1=1$; Balmer (Visible): $n_1=2$; Paschen (IR): $n_1=3$

■ Nuclear Physics

Radioactive decay: $N = N_0 \cdot e^{-(\lambda t)}$

Half-life: $T(1/2) = 0.693 / \lambda$

Activity $A = \lambda N$; Mass-energy: $E = mc^2$

Binding energy per nucleon indicates nuclear stability

■ Photoelectric + nuclear decay - 4-6 marks

- Photoelectric: intensity affects number of electrons, NOT their energy
- Beta- decay: neutron $\rightarrow$ proton; Beta+ decay: proton $\rightarrow$ neutron

- Work function and threshold frequency are material properties
- Nuclear radius $R = R_0 \cdot A^{(1/3)}$; $R_0 = 1.2 \text{ fm}$

Ch 16 ** Semiconductor Devices

■ Key Concepts

- Intrinsic: $n_e = n_h$; n-type: electrons majority; p-type: holes majority
- p-n junction: depletion layer, barrier potential ($\sim 0.7 \text{ V Si}$)
- Forward bias: reduces barrier; Reverse bias: increases barrier
- Zener diode: voltage regulation in reverse bias

■ Logic Gates

AND: $Y = A \cdot B$; OR: $Y = A + B$; NOT: $Y = A'$

NAND = NOT(AND); NOR = NOT(OR)

XOR: $Y = A \text{ xor } B = AB' + A'B$

De Morgan's: $(AB)' = A' + B'$; $(A + B)' = A' \cdot B'$

■ Diode characteristics + logic gates - 2-3 marks

Ch 1 ** Some Basic Concepts of Chemistry

■ Key Concepts

- Atomic mass, molecular mass, molar mass
- Mole concept: $1 \text{ mol} = 6.022 \times 10^{23}$ particles
- Empirical vs Molecular formula
- Stoichiometry: mole-mass-volume relationships
- Limiting reagent, % yield, % purity

■ Important Formulas

Moles = mass(g) / molar mass

Moles = volume(L) / 22.4 (STP, ideal gas)

Molarity M = moles of solute / volume(L)

% by mass = (mass solute / mass solution) x 100

■ Mole concept calculations - 4-5 marks

- Find limiting reagent: divide moles by stoichiometric coefficient
- Empirical formula: divide all moles by smallest mole ratio

Ch 2 ** Structure of Atom

■ Atomic Models

- Thomson: plum-pudding model
- Rutherford: nuclear model (gold foil experiment)
- Bohr: quantised orbits (hydrogen); $E_n = -13.6/n^2 \text{ eV}$
- Quantum model: orbitals, 4 quantum numbers (n, l, ml, ms)

■ Quantum Numbers and Orbital Rules

n = principal; l = 0 to n-1 (s,p,d,f); ml = -l to +l; ms = +/- 1/2

Aufbau: fill lowest energy first

Pauli: max 2 electrons per orbital (opposite spin)

Hund's: maximize unpaired electrons in degenerate orbitals

■ Electronic Configuration

- Exceptional configs: Cr (3d⁵ 4s¹), Cu (3d¹⁰ 4s¹)
- Magnetic property: paramagnetic (unpaired e-) vs diamagnetic

■ Electronic configuration + quantum numbers - guaranteed

Ch 3 ** Periodic Table & Periodicity

■ Periodic Trends (across period ->; down group v)

- Atomic radius: -> decreases; down increases
- Ionisation energy: -> increases; down decreases
- Electron affinity: -> increases; down decreases (exceptions: N, O)
- Electronegativity: -> increases; down decreases (Pauling scale)
- Metallic character: -> decreases; down increases

■ Important Groups

- Group 1 (Alkali): most reactive metals; Li smallest, Cs largest
- Group 17 (Halogens): F most electronegative
- Group 18 (Noble gases): zero electron affinity (He, Ne)
- Transition metals: variable oxidation states, coloured compounds

■ Ionisation energy exceptions (N > O) - trick question

- EA of F < Cl due to small size causing electron-electron repulsion
- Be, Mg have lower EA than their neighbours

Ch 4 *** Chemical Bonding & Molecular Structure

■ Types of Bonding

- Ionic: electron transfer; forms crystal lattice
- Covalent: electron sharing; can be polar or non-polar
- Coordinate/Dative: both electrons from same atom
- Metallic: electron sea model

■ VSEPR Theory

BP=2: linear (CO₂); BP=3: trigonal planar (BF₃)

BP=4: tetrahedral (CH₄, 109.5 deg); with lone pairs -> bent/pyramidal

NH₃: pyramidal (107 deg); H₂O: bent (104.5 deg)

Repulsion order: LP-LP > LP-BP > BP-BP

■ Hybridisation and Bond Order

sp: linear; sp²: trigonal planar; sp³: tetrahedral

sp³d: trigonal bipyramidal; sp³d²: octahedral

Bond order = (bonding e⁻ - antibonding e⁻) / 2

Higher bond order -> shorter, stronger bond

■ Hybridisation + VSEPR + bond order - 5-6 marks

- H-O-H angle < tetrahedral due to lone pairs on O
- MO theory: O₂ is paramagnetic (2 unpaired electrons in pi* orbitals)

Ch 5 ** States of Matter

■ Gas Laws

Boyle's: $PV = \text{const}$ (T constant)

Charles's: $V/T = \text{const}$ (P constant)

Avogadro: V proportional to n (P, T constant)

Ideal gas: $PV = nRT$ (R = 8.314 J/mol.K)

Dalton's partial pressure: $P_{\text{total}} = \sum(p_i)$

Kinetic theory: $PV = (1/3) m N$

■ Real Gases

van der Waals: $(P + a n^2/V^2)(V - nb) = nRT$

a = intermolecular attraction; b = volume of molecules

Compressibility $Z = PV/(nRT)$; ideal $Z = 1$

■ Ideal gas law + van der Waals - common numericals

Ch 6 *** Thermodynamics

■ Key Quantities

$\Delta H = \Delta U + \Delta n_g \cdot RT$ (Δn_g = moles gaseous products - reactants)

Hess's law: $\Delta H = \sum(\Delta H \text{ products}) - \sum(\Delta H \text{ reactants})$

Bond enthalpy: $\Delta H_{\text{rxn}} = \sum(\text{BE broken}) - \sum(\text{BE formed})$

$\Delta S_{\text{universe}} = \Delta S_{\text{system}} + \Delta S_{\text{surroundings}} \geq 0$

Gibbs: $\Delta G = \Delta H - T\Delta S$; $\Delta G < 0 \rightarrow$ spontaneous

$\Delta G_{\text{standard}} = -RT \ln K = -nF E_{\text{standard}}$

■ Spontaneity Summary

$\Delta H < 0, \Delta S > 0$: always spontaneous
 $\Delta H > 0, \Delta S < 0$: never spontaneous
 $\Delta H < 0, \Delta S < 0$: spontaneous at low T
 $\Delta H > 0, \Delta S > 0$: spontaneous at high T

■ ΔG and equilibrium relationship - 3-4 marks

Ch 7 *** Equilibrium

■ Chemical Equilibrium

$K_c = \frac{[C]^c [D]^d}{[A]^a [B]^b}$ for $aA + bB = cC + dD$
 $K_p = K_c \cdot (RT)^{\Delta n_g}$
 $Q < K$: forward reaction; $Q > K$: reverse reaction
Le Chatelier: system shifts to oppose the disturbance

■ Ionic Equilibrium

$pH = -\log[H^+]$; $pOH = -\log[OH^-]$; $pH + pOH = 14$
 $K_a \times K_b = K_w = 1e-14$ (at 25 C)
Degree of hydrolysis $h = \sqrt{K_w / (K_a \cdot C)}$ (salt of weak acid)
Buffer $pH = pK_a + \log([A^-]/[HA])$ (Henderson-Hasselbalch)

■ Buffer equations + K_{sp} /solubility - 4-5 marks

- For K_{sp} : if $Q > K_{sp} \rightarrow$ precipitation occurs
- Common ion effect reduces solubility

Ch 8 *** Redox Reactions & Electrochemistry

■ Key Concepts

- Oxidation: loss of e^- / increase in oxidation state
- Reduction: gain of e^- / decrease in oxidation state
- Oxidising agent: gets reduced; Reducing agent: gets oxidised

■ Electrochemistry Formulas

$E_{\text{cell}} = E_{\text{cathode}} - E_{\text{anode}}$
Nernst: $E = E_{\text{standard}} - \frac{RT}{nF} \ln Q = E_{\text{standard}} - \frac{0.0592}{n} \log Q$ (at 25 C)
 $\Delta G_{\text{standard}} = -nF E_{\text{standard}}$; $K = e^{(nFE_{\text{standard}}/RT)}$
Faraday: $m = Z \cdot I \cdot t = (M / nF) \times I \cdot t$
Kohlrausch: $\Lambda_m = \Lambda_m^{\text{standard}} - K \cdot \sqrt{C}$ (strong electrolyte)

■ Nernst equation + electrolysis (Faraday) - 4+ marks

- Higher SRP $\rightarrow$ better oxidising agent (placed at cathode)
- $E_{\text{cell}} > 0 \rightarrow$ spontaneous; $E_{\text{cell}} < 0 \rightarrow$ non-spontaneous

Ch 9 ** Coordination Compounds

■ Terminology

- Central metal atom/ion + ligands = coordination entity
- Coordination number: number of ligand atoms directly bonded
- Ligands: monodentate (Cl^- , NH_3), bidentate (en), polydentate (EDTA)
- Chelates: cyclic complexes (more stable)

■ IUPAC Naming

- Name ligands first (alphabetically), then metal with oxidation state
- Anionic ligands end in -o; anionic complex name ends in -ate

- Example: $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$ = hexaamminecobalt(III) chloride

■ Isomerism

- Structural: linkage, ionisation, coordination, solvate
- Stereoisomerism: geometric (cis/trans), optical (d/l, enantiomers)

■ Naming and isomerism - 2-3 marks

Ch 10 *** Organic Chemistry - Basic Principles

■ Reaction Intermediates

- Carbocations ($3 > 2 > 1 > \text{methyl}$); stabilised by hyperconjugation
- Carbanions (stability in opposite order)
- Free radicals: planar, sp^2 hybridised
- Carbenes: sp^2 or sp^3 depending on spin state

■ Named Reactions

- Aldol condensation: beta-hydroxy carbonyl compound (base, heat $\rightarrow$ unsaturated)
- Cannizzaro: self-redox of non-enolisable aldehydes
- Friedel-Crafts: alkylation (AlCl_3); acylation (AlCl_3)
- Kolbe: phenol + CO_2 + $\text{NaOH} \rightarrow$ salicylate
- Reimer-Tiemann: phenol + $\text{CHCl}_3/\text{OH}^- \rightarrow$ salicylaldehyde
- Sandmeyer: $\text{ArN}_2^+ + \text{Cu-halide} \rightarrow \text{Ar-X}$
- Hoffmann degradation: amide + $\text{Br}_2/\text{NaOH} \rightarrow$ amine

■ Reaction Types

- SN_1 : unimolecular; 3 degree favoured; racemisation
- SN_2 : bimolecular; 1 degree favoured; inversion (Walden)
- E_1 vs E_2 : Saytzev product (more substituted alkene preferred)
- Markovnikov: H adds to less substituted carbon in HX addition

■ Mechanisms + named reactions - 8-10 marks in organic

- EAS: activating groups (OH , NH_2) $\rightarrow$ ortho/para; deactivating (NO_2) $\rightarrow$ meta
- Acidity: carboxylic acids $>$ phenols $>$ alcohols $>$ water

Ch 11 ** Hydrocarbons

■ Key Reactions

- Alkanes: free radical halogenation (light/heat)
- Alkenes: electrophilic addition (HX , X_2 , H_2O); ozonolysis
- Alkynes: acidic H (terminal); addition follows Markovnikov
- Benzene: EAS (halogenation, nitration, sulfonation, Friedel-Crafts)

■ Identification Tests

- Alkenes: decolourise $\text{Br}_2(\text{aq})$, KMnO_4 (Baeyer's test)
- Terminal alkynes: precipitate with $\text{AgNO}_3/\text{NH}_3$ (silver acetylide)
- Benzene: does NOT decolourise $\text{Br}_2(\text{aq})$ without catalyst

■ EAS on benzene + directing groups - common

Ch 12 * Biomolecules, Polymers & Chemistry in Everyday Life

■ Biomolecules

- Carbohydrates: monosaccharides (glucose, fructose), disaccharides (sucrose), polysaccharides
- Proteins: alpha-amino acids joined by peptide bonds; 1, 2, 3, 4 degree structure
- Enzymes: biological catalysts; lock-and-key specificity

- Nucleic acids: DNA (deoxyribose, ATGC), RNA (ribose, AUGC)

■ Polymers

- Addition: polyethene, PVC, polystyrene (chain growth)
- Condensation: Nylon-6,6; Terylene/Dacron; Bakelite (step growth)
- Natural rubber: cis-1,4-polyisoprene; Vulcanisation: cross-linked with sulfur

■ Polymer classification + Nylon-6,6 / Terylene monomers - easy marks

Ch 13 *** p-Block Elements (Groups 13-18)

■ Group 15 - Nitrogen Family

- N₂ inert due to strong N triple-bond N bond (945 kJ/mol)
- NH₃: pyramidal; H-bond; basic; forms blue colour with CuSO₄
- HNO₃: oxidising acid; passivates iron and aluminium
- P: allotropes - white P (toxic), red P, black P

■ Group 16 - Oxygen Family

- O₃ (ozone): angular; has dipole moment; oxidising; decomposes with UV
- H₂SO₄ (conc.): dehydrating, oxidising, non-volatile; fuming with oleum
- SO₂: reducing agent; bleaching is reversible (decolourises KMnO₄)

■ Group 17 - Halogens

- F: strongest oxidising halogen (high EA + low bond dissociation energy)
- Cl₂: pale yellow-green; bleaching due to nascent oxygen
- Interhalogen compounds: ClF₃, BrF₅, IF₇

■ Group 18 - Noble Gases

- All monoatomic; stable octets (He: duplet)
- Xe compounds: XeF₂ (linear), XeF₄ (square planar), XeF₆ (distorted octahedral)

■ Oxoacids of P, S; properties of halogens - 4-5 marks

Ch 14 ** d- and f-Block Elements

■ Transition Metals - Properties

- High melting/boiling points; good conductors
- Variable oxidation states due to (n-1)d and ns electrons
- Coloured ions: d-d transitions (crystal field splitting)
- Catalytic activity: Fe in Haber process, V₂O₅ in Contact process
- Tendency to form complexes; exhibit magnetic properties

■ Important Compounds

KMnO₄: Mn in +7; strong oxidiser; different reactions in acid/neutral/alkaline

K₂Cr₂O₇: Cr in +6; dichromate in acid -> Cr³⁺ (green)

Lanthanide contraction: similar radii -> similar chemistry of 5d elements

■ KMnO₄ reactions + oxidation states - easy 2 marks

Ch 1 * Sets, Relations & Functions

■ Sets

$$n(A \cup B) = n(A) + n(B) - n(A \cap B)$$

$$n(A \cup B \cup C) = n(A) + n(B) + n(C) - n(A \cap B) - n(B \cap C) - n(A \cap C) + n(A \cap B \cap C)$$

$$\text{De Morgan's: } (A \cup B)' = A' \cap B'; (A \cap B)' = A' \cup B'$$

■ Relations and Functions

- Types: reflexive, symmetric, antisymmetric, transitive, equivalence
- Function types: injective (one-one), surjective (onto), bijective
- Composition: $(f \circ g)(x) = f(g(x))$; inverse exists iff function is bijective

Ch 2 ** Complex Numbers

■ Key Formulas

$$z = a + ib; |z| = \sqrt{a^2 + b^2}; \arg z = \arctan(b/a)$$

$$\text{Conjugate } z_{\text{bar}} = a - ib; z * z_{\text{bar}} = |z|^2$$

$$\text{Polar form: } z = r(\cos \theta + i \sin \theta) = r * e^{i\theta}$$

$$\text{De Moivre: } (\cos \theta + i \sin \theta)^n = \cos(n\theta) + i \sin(n\theta)$$

$$\text{Cube roots of unity: } 1, \omega, \omega^2; 1 + \omega + \omega^2 = 0; \omega^3 = 1$$

■ Cube roots of unity + modulus/argument - common

- For z on unit circle: $|z| = 1 \rightarrow z^{-1} = z_{\text{bar}}$
- Loci: $|z-a| = r$ (circle); $|z-a| = |z-b|$ (perpendicular bisector)

Ch 3 *** Quadratic Equations & Inequalities

■ Key Results

$$\text{Roots: } x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$\text{Sum of roots } \alpha + \beta = -b/a; \text{ Product } \alpha\beta = c/a$$

$$\text{Discriminant } D = b^2 - 4ac$$

$$D > 0: \text{ real distinct; } D = 0: \text{ equal; } D < 0: \text{ complex conjugate pair}$$

$$\text{Equation with roots } \alpha, \beta: x^2 - (\alpha + \beta)x + \alpha\beta = 0$$

■ Nature and Location of Roots

- Both roots positive: $D \geq 0, \alpha + \beta > 0, \alpha\beta > 0$
- One root in (p, q) : $f(p) \cdot f(q) < 0$
- Both roots in (p, q) : $D \geq 0, f(p) > 0, f(q) > 0, p < -b/2a < q$

■ Sum/product of roots + quadratic inequalities - 3-4 marks

Ch 4 *** Sequences & Series

■ AP

$$a_n = a + (n-1)d; S_n = \frac{n}{2}[2a + (n-1)d] = \frac{n}{2}(a + l)$$

$$AM = \frac{a + b}{2}$$

■ GP

$$a_n = a * r^{(n-1)}; S_n = \frac{a(1 - r^n)}{(1 - r)} \quad (r \neq 1)$$

$$S_{\infty} = \frac{a}{(1-r)} \text{ if } |r| < 1$$

$$GM = \sqrt{a * b}$$

■ HP and Special Series

HP: reciprocals form AP; $HM = \frac{2ab}{a+b}$

$AM \geq GM \geq HM$ (for positive numbers)

$\sum(n) = \frac{n(n+1)}{2}$; $\sum(n^2) = \frac{n(n+1)(2n+1)}{6}$; $\sum(n^3) = [\frac{n(n+1)}{2}]^2$

■ Series sum + AM-GM inequality - 4-5 marks

Ch 5 *** Permutations, Combinations & Binomial Theorem

■ Key Formulas

$P(n,r) = \frac{n!}{(n-r)!}$

$C(n,r) = \frac{n!}{r!(n-r)!} = C(n, n-r)$

Circular permutation: $(n-1)!$ (distinct objects)

With repetition: n^r ; Without: $P(n,r)$

■ Binomial Theorem

$(a+b)^n = \sum C(n,r) a^{n-r} b^r$

$T_{(r+1)} = C(n,r) a^{n-r} b^r$ (general term)

Middle term: $T_{(n/2 + 1)}$ for even n ; $T_{((n+1)/2)}$ and $T_{((n+3)/2)}$ for odd n

Sum of coefficients: put $a = b = 1 \rightarrow 2^n$

■ Binomial general term + middle term - 3 marks

■ Identical objects: $C(n+r-1, r-1)$ ways to distribute r objects in n groups

■ Derangements (no object in original place): $D_n = n!(1 - \frac{1}{1!} + \frac{1}{2!} - \dots)$

Ch 6 *** Matrices & Determinants

■ Determinant Properties

- Swapping rows/columns: sign of determinant changes
- Multiplying a row by k : determinant multiplies by k
- Identical rows/columns: determinant = 0
- $\det(AB) = \det(A) \cdot \det(B)$; $\det(A^T) = \det(A)$

■ Inverse and Rank

$A^{-1} = \frac{\text{adj}(A)}{\det(A)}$ (exists iff $\det \neq 0$)

Cramer's rule: $x_i = \frac{D_i}{D}$

Cayley-Hamilton: every matrix satisfies its characteristic equation

Rank = max number of linearly independent rows/columns

■ 3x3 determinant + system of equations - 4-5 marks

■ For consistent system: $\text{rank}(A) = \text{rank}(\text{augmented matrix})$

■ $\det(kA) = k^n \det(A)$ for $n \times n$ matrix

Ch 7 *** Trigonometry

■ Identities

$\sin^2(\theta) + \cos^2(\theta) = 1$; $1 + \tan^2(\theta) = \sec^2(\theta)$; $1 + \cot^2(\theta) = \text{cosec}^2(\theta)$

$\sin(2\theta) = 2\sin(\theta)\cos(\theta)$; $\cos(2\theta) = \cos^2(\theta) - \sin^2(\theta)$

$\cos(2\theta) = 1 - 2\sin^2(\theta) = 2\cos^2(\theta) - 1$

$\tan(2\theta) = \frac{2\tan(\theta)}{1 - \tan^2(\theta)}$

$\sin(A \pm B) = \sin A \cos B \pm \cos A \sin B$

$\cos(A \pm B) = \cos A \cos B \mp \sin A \sin B$

■ Inverse Trig and Equations

$\sin^{-1}(-1)(x) + \cos^{-1}(-1)(x) = \frac{\pi}{2}$; $\tan^{-1}(-1)(x) + \cot^{-1}(-1)(x) = \frac{\pi}{2}$

$\tan^{-1}(-1)(x) + \tan^{-1}(-1)(y) = \tan^{-1}(-1)\left[\frac{(x+y)}{(1-xy)}\right]$ ($xy < 1$)

General soln: $\sin(\theta) = \sin(\alpha) \rightarrow \theta = n\pi + (-1)^n \alpha$
 $\cos(\theta) = \cos(\alpha) \rightarrow \theta = 2n\pi \pm \alpha$
 $\tan(\theta) = \tan(\alpha) \rightarrow \theta = n\pi + \alpha$

■ Triangle Properties

Sine rule: $a/\sin(A) = b/\sin(B) = c/\sin(C) = 2R$

Cosine rule: $a^2 = b^2 + c^2 - 2bc \cos(A)$

Area = $(1/2)ab \sin(C) = \sqrt{s(s-a)(s-b)(s-c)}$ (Heron's formula)

■ Trig identities + equations - 5-6 marks

- Domain of $\sin^{-1}$ is $[-1, 1]$; range is $[-\pi/2, \pi/2]$
- In general solutions, n can be any integer

Ch 8 *** Coordinate Geometry - Straight Lines & Conics

■ Straight Lines

Slope $m = (y_2 - y_1)/(x_2 - x_1) = \tan(\theta)$

Distance from point (x_1, y_1) to $ax + by + c = 0$: $|ax_1 + by_1 + c| / \sqrt{a^2 + b^2}$

Angle between lines: $\tan(\theta) = |(m_1 - m_2)/(1 + m_1 m_2)|$

■ Conic Sections

Circle: $(x-h)^2 + (y-k)^2 = r^2$; general: $x^2 + y^2 + 2gx + 2fy + c = 0$

Parabola: $y^2 = 4ax$ (focus $(a, 0)$, directrix $x = -a$)

Ellipse: $x^2/a^2 + y^2/b^2 = 1$; $e = c/a < 1$; $b^2 = a^2 - c^2$

Hyperbola: $x^2/a^2 - y^2/b^2 = 1$; $e > 1$; $b^2 = c^2 - a^2$

■ Key Tangent/Normal Results

Parabola $y^2 = 4ax$: tangent at $(at^2, 2at) \rightarrow ty = x + at^2$

Ellipse: tangent at (x_1, y_1) : $xx_1/a^2 + yy_1/b^2 = 1$

Chord of contact from external point: same form as tangent equation

■ Conics (parabola, ellipse) + tangents - 5-6 marks

Ch 9 *** 3D Geometry & Vectors

■ Vectors

Dot product: $a \cdot b = |a||b| \cos(\theta)$

Cross product: $|a \times b| = |a||b| \sin(\theta)$; direction by right-hand rule

Scalar triple product: $[a \ b \ c] = a \cdot (b \times c) = \det[a, b, c]$

If $[a \ b \ c] = 0$: vectors are coplanar

■ 3D Lines and Planes

Line: $(x-x_1)/l = (y-y_1)/m = (z-z_1)/n$

Plane: $ax + by + cz = d$; normal vector (a, b, c)

Distance from point to plane: $|ax_1 + by_1 + cz_1 - d| / \sqrt{a^2 + b^2 + c^2}$

Angle between planes: $\cos(\theta) = |a_1 a_2 + b_1 b_2 + c_1 c_2| / (|n_1| |n_2|)$

■ Vector operations + distance between lines - 4-5 marks

Ch 10 *** Limits, Continuity & Differentiability

■ Standard Limits

$\lim_{x \rightarrow 0} \sin(x)/x = 1$; $\lim_{x \rightarrow 0} \tan(x)/x = 1$

$\lim_{x \rightarrow 0} (1+x)^{1/x} = e$; $\lim_{x \rightarrow \infty} (1+1/x)^x = e$

$\lim_{x \rightarrow 0} (a^x - 1)/x = \ln(a)$; $\lim_{x \rightarrow 0} (e^x - 1)/x = 1$

L'Hopital's rule: $\lim f(x)/g(x) = \lim f'(x)/g'(x)$ ($0/0$ or ∞/∞ form)

■ Continuity and Differentiability

- Continuous at a : $\lim_{x \rightarrow a} f(x) = f(a)$
- Differentiable at a : $LHD = RHD = f'(a)$
- Differentiable implies Continuous (converse not true)
- $|x|$ is continuous at 0 but NOT differentiable at 0

■ L'Hopital's + continuity/differentiability - 4-5 marks

Ch 11 *** Differentiation & Applications

■ Standard Derivatives

$d/dx[x^n] = n \cdot x^{(n-1)}$; $d/dx[e^x] = e^x$; $d/dx[\ln x] = 1/x$
 $d/dx[\sin x] = \cos x$; $d/dx[\cos x] = -\sin x$; $d/dx[\tan x] = \sec^2(x)$
 $d/dx[\sin^{-1}(x)] = 1/\sqrt{1-x^2}$; $d/dx[\tan^{-1}(x)] = 1/(1+x^2)$
Chain rule: $d/dx[f(g(x))] = f'(g(x)) \cdot g'(x)$

■ Applications

Maxima/minima: $f'=0$; $f'' > 0 \rightarrow \min$; $f'' < 0 \rightarrow \max$
Mean Value Theorem: $f'(c) = [f(b)-f(a)] / (b-a)$
Rolle's theorem: $f(a)=f(b) \rightarrow f'(c)=0$ for some c in (a,b)
Rate of change: $dy/dx = (dy/dt) / (dx/dt)$

■ Maxima/minima application problems - 3-4 marks

- For implicit differentiation: differentiate both sides with respect to x
- Parametric: $dy/dx = (dy/dt)/(dx/dt)$; d^2y/dx^2 needs careful application

Ch 12 *** Integration & Its Applications

■ Standard Integrals

$\int x^n dx = x^{(n+1)}/(n+1) + C$ ($n \neq -1$); $\int (1/x) dx = \ln|x| + C$
 $\int e^x dx = e^x + C$; $\int a^x dx = a^x/\ln(a) + C$
 $\int \sin x dx = -\cos x + C$; $\int \cos x dx = \sin x + C$
 $\int \sec^2(x) dx = \tan x + C$; $\int \operatorname{cosec}^2(x) dx = -\cot x + C$
 $\int (1/\sqrt{a^2-x^2}) dx = \sin^{-1}(x/a) + C$
 $\int (1/(a^2+x^2)) dx = (1/a) \tan^{-1}(x/a) + C$

■ Definite Integrals and Properties

$\int_0^a f(x) dx = \int_0^a f(a-x) dx$
 $\int_{-a}^a f(x) dx = 2 \cdot \int_0^a f(x) dx$ (even f); $= 0$ (odd f)
By parts: $\int (u \cdot v) dx = u \cdot \int v dx - \int (u' \cdot \int v dx) dx$
ILATE rule: Inverse, Logarithm, Algebraic, Trigonometric, Exponential

■ Area Under Curve

Area = $\int_a^b |f(x)| dx$
Between two curves: $\int_a^b [f(x)-g(x)] dx$ ($f > g$ in $[a,b]$)

■ Integration by parts + area under curves - 5-6 marks

Ch 13 ** Differential Equations

■ Types and Methods

- Variable separable: $f(y)dy = g(x)dx$
- Homogeneous: substitute $y = vx$; reduces to separable form
- Linear: $dy/dx + Py = Q$; IF = $e^{\int P dx}$; solution: $y \cdot IF = \int (Q \cdot IF) dx$
- Exact: $M dx + N dy = 0$; check $\partial M / \partial y = \partial N / \partial x$

■ Key Definitions

- Order: highest derivative present in the equation
- Degree: power of highest-order derivative (when polynomial in derivatives)
- General solution contains as many arbitrary constants as the order

■ Linear DE + variable separable - 3-4 marks

Ch 14 *** Probability & Statistics

■ Key Formulas

$$P(A \cup B) = P(A) + P(B) - P(A \cap B)$$

$$\text{Conditional: } P(A|B) = P(A \cap B) / P(B)$$

$$\text{Bayes': } P(A_i|B) = P(A_i)P(B|A_i) / \sum [P(A_j)P(B|A_j)]$$

$$\text{Independent events: } P(A \cap B) = P(A) \cdot P(B)$$

■ Distributions

$$\text{Binomial: } P(X=r) = C(n,r) p^r q^{(n-r)}; \text{ Mean} = np; \text{ Var} = npq$$

$$\text{Poisson: } P(X=k) = e^{(-\lambda)} \lambda^k / k!; \text{ Mean} = \text{Var} = \lambda$$

$$\text{Normal: symmetric about mean; 68-95-99.7 rule}$$

■ Statistics

$$\text{Mean} = \sum(fx) / \sum(f); \text{ Median} = L + [(n/2 - F)/f] \times h$$

$$\text{Mode} = L + [(f_1 - f_0) / (2f_1 - f_0 - f_2)] \times h$$

$$\text{Variance } \sigma^2 = \sum[f(x - \bar{x})^2] / n; \text{ SD} = \sqrt{\text{variance}}$$

$$\text{Coefficient of variation} = (\sigma / \bar{x}) \times 100$$

■ Bayes' theorem + binomial distribution - 4-5 marks

$$\blacksquare \text{ For mutually exclusive events: } P(A \cup B) = P(A) + P(B)$$

$$\blacksquare P(A') = 1 - P(A); P(A \cap B) = 0 \text{ if mutually exclusive}$$

Ch 15 * Mathematical Reasoning & Linear Programming

■ Mathematical Reasoning

- Proposition: declarative sentence (True or False)
- Negation ($\sim p$), Conjunction ($p \text{ AND } q$), Disjunction ($p \text{ OR } q$)
- Implication $p \rightarrow q$ (false only when $p=T, q=F$)
- Biconditional $p \leftrightarrow q$; Contrapositive $\sim q \rightarrow \sim p$ (equivalent to $p \rightarrow q$)

■ Linear Programming

- Formulate: objective function $Z = ax + by$; constraints as inequalities
- Feasible region: intersection of all constraint half-planes
- Optimal solution always at a corner (vertex) of feasible region
- If feasible region is unbounded: verify whether max/min exists

■ LPP corner-point method - 2-3 marks